The Choice Between Pension Reform Options

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Abstract

We evaluate the likelihood of different reforms of an unsustainable pay–as–you–go pension system. Individual agents' preferences are determined for 15 age groups and all possible levels of wealth to account for expectations held prior to a reform. Moreover, we introduce "indifference bands" in an age–savings plane to assess the robustness of our findings. Majority votes tend to favour distortionary tax increases over benefit reductions. Tax–benefit linkages and especially altruistic preferences can lead to more efficient voting outcomes. Although wealth holdings is a crucial variable in determining individual preferences, the ranking of reforms is generally not affected.

JEL–Classification: H55, D91, D72

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1 Introduction

In most countries a pay–as–you–go (PAYG) public pension system constitutes by far the most important fraction of the governent budget in which taxes are earmarked.[1] At the same time, mainly due to demographic changes and a slow–down in productivity growth, there is a growing mismatch between earmarked taxes and current and future claims to the system. It is obvious that most public pension schemes in industrialized countried are not sustainable without sizeable adjustments. The already delicate financial situation will further worsen with the ageing of the baby–boomers, and will last well into the 21st century. Although opinions differ about the extent of the problem, it is generally agreed, that "something has to be changed". The question is then, *how* the public pension scheme will be changed.

Different options to reform current pay–as–you–go pension systems entail dramatically different short– und long run welfare effects for different generations and hence largely affect the outcome in a democratic decision. An individual's preferences with regard to the post–reform pension scheme depends on her personal characteristics as well as on her expectations prior to the necessary policy change. Although welfare comparisons are difficult to carry out in a changing environment, we can take a young agent's utility in the new steady state after the reform as a suitable measure of efficiency. Using the paper's parameterization and the necessary pension parameter adjustments forecasted for Switzerland, a young agent gains 8.2% (3.7%) in lifetime consumption if the adjustment is a reduction in benefits rather than an increase in payroll taxes (consumption taxes).

In a political decision process, utility at birth will not be the decisive factor in designing and changing the pension system, however. In a democratic country, where votes are taken or the government is reelected, the likelihood of certain policy measures will depend on the demographic structure and the distribution of asset holdings, which in turn depends on past

[1] In addition to overall earmarking of taxes collected for social security, there is often also a relationship between taxes and benefits on an *individual level* by means a more or less specific individual tax–benefit linkage.

expectations. Moreover, the socioeconomic composition of society evolves over time, as people age and new generations are born. Thus, the dynamic system can be very difficult to analyze.

This paper explores one aspect of the discussion. We investigate the case in which an infeasible PAYG pension system is to be transfered into a feasible PAYG system.[2] We propose a simple way to evaluate the possibility of certain reform measures by means of a stylized voting model in an economy inhabited by 15 overlapping generations. To achieve our goal, we proceed in two steps. First, we determine individual agents' preferences over pension reform options at all ages, and a wide range of possible asset holdings to capture expectations prior to the vote. Moreover, we also determine how much two policy options differ in terms of lifetime consumption at each age and wealth level. In a second step, individual preferences are compared with the country's population structure. In common with previous authors, all reforms are assumed final. Policy options are ranked by means of pairwise comparisons. The presented approach can also be applied if the median voter approach fails, for example if people differ on more than one dimension. In order to get quantitative results of the proposed approach, the model is calibrated for the case of

[2] We therefore abstract from the possibility of changing the scheme all together, for example by introducing a fully funded pension scheme. However, we also explore the case in which benefits are closely related to benefits, as in a fully funded system. An IMF–study by Chand & Jaeger (1996) concludes that the fiscal costs of undertaking a shift to a fully funded system may be very high and that it might be preferable to fix the existing PAYG system instead. The political pressure against such a shift is presumably large unless compensating gains to living generations, who by their contributions have acquired an implicit right to future benefits, are sufficiently high.

PAYG systems suffer from two sources of inefficiencies compared to funded pension systems: First, the internal rate of return corresponds more or less to the sum of economic growth and the growth rate of the active population. In times of sluggish growth and especially declining fertiliy rates, it is much smaller than the real interest rate, the internal rate of return for funded systems. Second, missing linkages in PAYG systems deteriorate the efficiency even more, as payroll taxes increase labour supply distortions. However, there is no reason not to link past contributions to future benefits even in a PAYG system. This issue will also be covered in the paper.

Switzerland with its direct democracy.

There is a large literature on the public choice approach to public pensions.[3] An early paper by Aaron (1966) argues that the median voter has an incentive to perpetuate a PAYG pension system, although it reduces everyone's lifetime utility. Browning (1975) analyzes a three–overlapping generations model in which two working generations produce a perishable consumption good, while the old generation is unproductive and is left without means in the absence of a transfer system. His argument for an overprovision of public pensions runs as follows: As the median voter is middle–aged, he gains from higher benefits, as he is only confronted with higher contributions for a short period. Boadway & Wildasin (1989) extend Browning's analysis in assuming that individuals can save but are not allowed to borrow. Their model generates cycles of over– and underprovision of pensions relative to a steady state which is driven by the assumption that individuals do not anticipate future changes to the scheme. Hu (1982) analyzes the Browning model under the assumption that revoting is possible and that the outcomes of future votes are uncertain due to uncertainty about future demographic conditions and the behaviour of future agents. Uncertainty plays a crucial role in his analysis, as it restricts the desired level of social security and does not lead to corner solutions. Sjoblom (1985) models the choice of pension levels of successive generations as a dynamic game, in which failures to maintain the existing level will be punished by the next generation. Although a lot of insight can be gained by these contributions, the existing literature has little to say about a democratic society's preferences in reality. Often the relevant choice is not the introduction or abolishment of a public pension scheme, but rather the extent to which it should be adjusted to meet the existing needs and fiscal constraints.

The analysis of this paper differs from previous work in a number of ways. First, by considering a richer multiperiod life–cycle structure, the proposed model can give a more realistic analysis of policy preferences at all ages than would be possible in the two– or

[3] An excellent review of the political economy of public pension systems can be found in Verbon (1990).

three–period models of classical voting models. Although the model is too complicated to yield analytical solutions, it can easily be calibrated to match the data and can therefore offer numerical forecasts for future votes. Second, in addition to determining the median voter, the model can provide a measure for the distance (in terms of utility) between two reforms, as utility differences between two types of parameter adjustments might be small for a lengthy part in an individual's life. For this purpose, a simple device is presented to derive “indifference bands” around the age where people are indifferent between two reforms. Our setting is flexible enough to explore a variety of extensions. The importance of heterogenous agents and the impact of individual linkages between taxes and future benefits can easily be assessed. Although the framework is applied to study the choice over pension reform options, it is general enough to consider other policy experiments which imply intergenerational distributions.

The paper is organized as follows. Section 2 gives an introduction to the underlying individual life–cycle model and utility comparisons. Moreover, we examine the role of age and asset holdings on individuals' preferences over reform types, and propose a way to derive indifference bands. We also explore how individual preferences translate into evaluating the likelihood of certain reform options. Section 3 describes the PAYG public pension system and discusses possible reforms. Calibration issues are explained in section 4. Section 5 presents first predictions for a benchmark case without tax–benefit linkages, and then explores the impact of different relationships between taxes and benefits. A sensitivity analysis on the used parameters is to be found in section 6. This section also includes results on a number of extensions, such as gradual reforms, heterogenous agents and the inclusion of altruism. Section 7 describes possible extensions, and section 8 summarizes the results and concludes.

2 The basic setup

To explore the preference structure of the society, we first analyse individuals' preferences over the life–cycle. In a second step we explore how individual choices translate into collective decision making. To keep the model tractable, a number of simplifying assumptions are imposed: Preferences are time separable and the instantaneous utility function $U[\cdot]$ depends on consumption $c(t)$ and leisure $l(t)$. Endogenous labour supply, which is missing from all previous contributions, is viewed as an important ingredient to our setup as it makes payroll taxes distortionary. A common argument in favour of reducing—or at least not increasing—taxes would be missed for exogenous labour supply.

Income opportunities are non–stochastic and known. Uncertainty in the model stems from two sources: first, an idiosyncratic mortality risk and second, uncertainty about the future parameters of the public pension system prior to the reform. There are no bequest or gift motives. We will, however, allow for some degree of altruism within the sensitivity analysis in section 6. Our economy is equiped with a single liquid asset which yields a constant real interest rate r. There is no wedge between borrowing and lending rates and agents can lend and borrow freely at the interest rate r. The assumption of fixed factor prices, an assumption common to the bulk of the literature, can be interpreted as representing a small open economy or a linear production technology.[4] Retirement is assumed to be induced by the age–wage profile and is therefore voluntary. However, the earnings profile and public pension parameters are such that people chose to retire at an age which is in line with reality.

[4] Variable factor prices would complicate the analysis of policy preferences dramatically, as individuals would have to predict future paths of factor prices as a result of the change in policy. Every generation is confronted with different profiles of factor prices and its preferences therefore have to be analyzed separately. The question is whether an omission of a general equilibrium feedback—which is also missing in previous works of Browning (1975) and Boadway & Wildasin (1989)—changes the results or is merely a second order phenomenon. The caveat is somewhat mitigated by the fact that the outcomes of collective decision making are fairly robust to variations in factor prices as is shown in section 6.

A complete analysis of the preference structure in a dynamical model, in which the nature of the reform will be determined by a vote, is inherently complicated. An individual's preferences depend not only on her age but also on the history of her expectations as well as the expected future reforms when the vote takes place. In order to make the model tractable, and in line with Boadway & Wildasin (1989) and other authors, it is assumed that all reforms are final. This assumption, can be justified on the grounds that large reforms to the public pension system occur relatively seldom. So it can be assumed that pension reforms affect an agent only once in her lifetime. Moreover, we do not have to make any assumptions about the interaction of generations in the future.

2.1 Individual life–cycle optimization

Let $\mathcal{S}$ be the set of reform policies, and let variables marked with superscript s depend on the chosen policy. Individuals may live up to age $J_{\max}$, after which death is certain. An agent, who votes at age J_V and carries a level of wealth $A_{\{J_V-1\}}$ from the previous period, maximizes his expected remaining lifetime utility

$$\mathcal{U}^s(J_V, A_{\{J_V-1\}}) = \max_{c,l} E\left(\sum_{j=J_V}^{J_{\max}} \beta^{j-1}\Psi_j U[(1-\nu^s)c_j, l_j]\middle| A_{\{J_V-1\}}\right), \tag{1}$$

where c_j and l_j denote consumption expenditures and leisure of an age j individual. Only net consumption $c_j(1-\nu)$ enters the utility function. Ψ_j is the probability of survival from birth to age j, and ν denotes the consumption tax earmarked for financing social security. In every period of their lives, agents are endowed with one unit of time which they can allocate to either leisure or labour, therefore $0 \leq l_j \leq 1$. Let e_j denote age–j labour productivity, w the constant real wage rate per efficiency unit of labour, and r the real rate of return on asset holdings. Then, the budget constraints of an individual can be written as

$$\begin{aligned}
(a_0 &= 0) \\
a_{J_V-1} &= A_{\{J_V-1\}} \\
a_j &= (1+r)a_{j-1} + (1-l_j)\, e_j\, (1-\tau^s)\, w + B^s - c_j
\end{aligned} \tag{2}$$

$$a_{J_{\max}} \geq 0$$

where a_j are the end–of–period asset holdings of an age–j–individual. B are social security benefits and τ denotes the proportional payroll tax earmarked to finance benefits.

To close the model, we have to specify a benefit formula, linking contributions and future benefits. In principle, future benefits are allowed to depend on individual characteristics, such as labour productivity and survival probabilities, and aggregate variables, such as the wage rate and fiscal parameters. From an individual perspective, the most important determinant, however, is the control variable labour supply l. A concise version of a benefit formula will therefore be

$$B^s = \begin{cases} 0, & j < J^{*,s} \\ B^s(l_1, ..., l_J; X^s), & j \geq J^{*,s} \end{cases} \tag{3}$$

where J^* is the legal retirement age and X stands for all individual and aggregate parameters used to compute benefits. Often, future benefits are linked in one way or another to past payroll tax contributions. Note, however, that consumption tax contributions cannot be earmarked on an individual level.

The agent computes his utility for each policy. The option with the highest utility will determine his vote. As reforms are final, no expectations about future variables are necessary. Note that utility is maximized conditional on asset holdings at the end of the previous period. In order to determine the relevant wealth prior to a reform for each age—or at least to identify a plausible range of pre–reform asset holdings—we would have to take account of past expectations. If preferences are time separable, however, asset holdings $A_{\{J_V-1\}}$ are a sufficient statistics for the entire history $H_{\{J_V-1\}}$ up to the voting date, with $H_{\{J_V-1\}}$ containing all relevant information of the past. We will circumvent the problem of not knowing past expectations by computing and comparing utilities for a wide range of possible asset holdings—which should include the "correct" value— at each age. This approach not only has the advantage that we do not have to make any arbitrary assumptions about pre–reform asset holdings, but it also serves as a robustness check on the decision of individuals.

2.2 Comparing utilities

As utilities are ordinal, a direct comparison of utilities of two pension reform options is generally not possible, apart from ranking them. We can, however, ask the following question: How much does one policy differ from another with respect to the level of consumption during the remainder of the life–cycle. Utilities are said to differ by ζ when the same utility as for the second policy option can be achieved by reducing consumption for the first policy by a fraction ζ for every remaining period in life, or formally

$$\mathcal{U}^{s_2}\left[\mathbf{c}^{s_2},\mathbf{l}^{s_2}\middle|A_{\{J_V-1\}}\right]=\mathcal{U}^{s_1}\left[(1-\zeta)\mathbf{c}^{s_1},\mathbf{l}^{s_1}\middle|A_{\{J_V-1\}}\right]$$

where $\mathbf{c}^{s_1,s_2}$ and $\mathbf{l}^{s_1,s_2}$ denote optimal consumption and leisure paths, respectively, for an age–J_V agent after reforms s_1 and s_2 . Comparing two policies can now be done easily by calculating the implicit difference in consumption ζ.

A particularly simple situation arises if instantaneous utility is specialized to the constant–intertemporal–elasticity–of–substitution (CIES) case,

$$U[c_j,l_j]=\frac{\left(c_j^{\theta}l_j^{1-\theta}\right)^{1-\sigma}}{1-\sigma}.$$

We can calculate the implied consumption reduction ζ of scheme s_2 relative to scheme s_1 as

$$\zeta=1-\left(\frac{\mathcal{U}^{s_2}}{\mathcal{U}^{s_1}}\right)^{\frac{1}{\theta(1-\sigma)}}.$$

2.3 Deriving “indifference bands”

As already pointed out, the difference between $\mathcal{U}^{s_1}(j,a)$ and $\mathcal{U}^{s_2}(j,a)$ can be small. As a measure of robustness, we therefore define some kind of “indifference bands” for comparing utilites by means of the implicit difference in lifetime consumption ζ. It can be argued that utilities are difficult to rank if they differ by less than a certain fraction λ in lifetime consumption. People are then said to be indifferent between schemes s_1 and s_2 at level λ if

$$|\zeta|\ \leq\ \lambda.$$

Given the level of asset holdings, we can define upper and lower bounds of a region in which agents are considered to be indifferent between two reforms, as $\underline{J}_\lambda(a)$ and $\overline{J}_\lambda(a)$, respectively. If, in addition, we define $J_0(a)$ to be the age in which an agent is exactly indifferent between two policies, i.e. $\mathcal{U}^{s_1}(J_0, a) = \mathcal{U}^{s_2}(J_0, a)$, we get

$$\underline{J}_\lambda(a) \leq J_0(a) \leq \overline{J}_\lambda(a).$$

2.4 Individual preferences and democratic decision making

Equipped with a way to explore preferences over reform options on the individual level, we may now ask how these preferences translate into collective decision making. Due to the assumption of constant factor prices and assuming homogeneity within a generation, society's preferences can be directly derived from a representative life–cycle agent's preferences. Although we assume here that the nature of a pension reform is decided on in a vote, alternative decision making procedures—for example by a parliament in a representative democracy—can be modeled on an analogous way. Unfortunately, as in most voting models, a problem occurs when more than two alternatives are at disposal. An agent might want to give his vote not for the most prefered alternative but for the second best, when the probability of his favorite policy being implemented is too small. To exclude strategic voting, we will make the assumption that only two reform alternatives will be considered simultaneously. Reforms are ranked by pairwise comparisons.

If agents within the same generation are homogenous and preferences are single peaked, it suffices to locate the median voter (mostly with respect to age) and to compare his/her age with the preference structure of different generations.[5] Majority voting equilibria will therefore always exist. To determine the median voter's age, the fraction of people under a certain age is computed. Let $\mu_j(t)$ be the number of people with age j and

[5] Note that as agents are homogenous within the same generation, it is not necessary to consider asset holdings as a second dimension in identifying the median voter. However, due to the difficulty to trace expectations before a vote is taken, we do not know asset holdings per age group—and consequently neither for the median voter—exactly.

$\mu(t) = \sum_{j \in \mathcal{J}} \mu_j(t)$ be the total population. The fraction $\upsilon_j(t)$ of people under or at age j is

$$\upsilon_j(t) \equiv \frac{\sum_{i \leq j} \mu_i(t)}{\mu(t)} \tag{4}$$

The median voter with respect to age is an agent of age J_{med} with $\upsilon_{J_{\text{med}}}(t) = 0.5$. In a second step, we have to identify a plausible range of asset holdings for the median voter in the economy. As can be seen in the analysis below, however, our results turn out to be fairly robust for a wide range of possible asset holdings.

Sometimes preferences are not monotonous with respect to age. Consider for example the case in which agents have to chose between an increase in the retirement age and an increase in consumption taxes to maintain the previous benefit level. For very young agents, an increase in retirement age is preferable over an increase in consumption taxes, as the latter distorts their consumption decision. For a very old agent, an increase in retirement age is also prefered as it does not harm him any more. The middle–aged however certainly favour an increase in consumption tax over an increase in retirement age as the latter has a far greater negative wealth effect than the former. Note, however, that preferences are still single–peaked, but ranking by age does not lead to a correct ranking of utilities.

In addition, the median voter framework is not applicable if a second dimension, apart from age, has to be considered. This is the case when agents within a generation are heterogenous, as for example in section 6.4. We then proceed as follows: The fraction of the population in favour of either reform is computed for each subgroup of the population. In addition, we can also compute the fraction of people whose decisions are not clear cut with respect to the measure λ, i.e. agents for which $\underline{J}_\lambda(a) \leq j \leq \overline{J}_\lambda(a)$.

3 Public pensions

The public pension system considered here is always a pay–as–you–go (PAYG) system in which the current young have to finance the pensions of the current old. Benefits B, which can be related to an agent's past earnings or other characteristics, are paid out after the legal retirement age J^*, regardless of whether the agent leaves the workforce or not. Pensions are financed by a proportional payroll tax τ and a proportional consumption tax ν on all consumption expenditures.[6]

A reform within a PAYG system is carried out by either cuts on the benefit side or increases in contribution rates. The former can be achieved by either reducing benefits B (or adjusting the tax–benefit linkage) or increasing the retirement age J^*. While a reduction in the benefit level and an offsetting increase in retirement age obviously lead to the same reduction in lifetime income for young agents, the political feasibility might be very different, as will be shown below. Contributions can be increased by either an increase in the payroll tax rate τ or an increase in the consumption tax rate ν.

3.1 Linkages

Although the current public pension systems are predominantly unfunded in many countries, benefits are often related to contributions to a certain extent. The important question in our context is how much agents *perceive* such a linkage. If they do, their labour supply and savings decisions are less distorted—even in PAYG systems—when the linkage is strong enough. Auerbach & Kotlikoff (1987) show that there may be significant efficiency gains in tightening the connection between marginal taxes paid and marginal pension benefits received.

Future benefits are allowed to depend on individual characteristics, such as labour productivity and survival probabilities, and aggregate variables, such as the wage rate and fiscal parameters. From an individual perspective, the most important determinant, however, is the control variable labour supply l. Agents are assumed to be fully aware of a benefit–tax linkage in the public pension system. In order to make the model tractable, however, this linkage is assumed to be equal for all agents whithin the same generation.

[6] Consumption taxes, as a way to finance social security, have entered the debate relatively late. They have received increasing political support lately, as they could shift—at least partially—the burden from the working generation to the elderly.

We consider a benefit formula of the following general nature:

$$B = B_0 + \alpha \sum_{j=1}^{J^{\max}} (1 - l_j) f_j \quad \text{for} \quad j \geq J^* \tag{5}$$

B_0 is a minimum pension level paid out regardless of previous contributions, and f_j represents relevant (individual) characteristics to which the benefit level is related. The parameter α will be determined by the relevant budget constraint of the pension system. Although the sum in (5) is taken over all periods, the final contribution year usually coincides with the period prior to official retirement, such that $f_j = 0$ for $j \geq J^*$.

The linkage introduces an additional state variable, which we call accumulated "pseudo claims". However, as is shown in appendix A, a system *with* individual linkages is computationally equivalent to a system *without* linkages and an implicit payroll tax $\tilde{\tau}_j$ for age–j agents, where

$$\tilde{\tau}_j \equiv \tau - \frac{\alpha f_j}{e_j w} \left\{ \frac{(1+r)^{\{\mathcal{J} - J^* - 1\}} - 1}{r(1+r)^{\mathcal{J} - j}} \right\}.$$

Note that in the presence of a tax–benefit linkage, the effective (distortionary) payroll tax rate is smaller or equal to the statutory level τ, In every period j, there is an amount of "virtual savings" due to the accumulation of funds for retirement. Combined wealth is then the sum of asset holdings and accumulated "virtual savings" as described in more details in appendix A.

4 Computation and calibration

4.1 Computation

The individual optimization problem is solved by means of numerical dynamic programming where decision rules are derived on a grid of possible values for asset holdings at each age. Individuals are assumed to be born at age 20 and to live for a maximum of 15 five–year periods to age 95. Although a dynamic programming approach is not strictly necessary in our context, as a by product of these computations, utility levels for each reform and each savings/age pair can directly be read off from the corresponding value function matrix. The indifference locus and indifference bands can be derived easily as contour lines in the age/savings plane. Contour lines corresponding to an equivalent change of 1, 3, and 5 percent of remaining lifetime consumption are also drawn in all figures below.

Plausible upper and lower bounds for asset holdings at each age (represented by dashed lines in the figures below) are estimated as follows: First, if an agent faces a high payroll tax combined with a high benefit level, both the need and the opportunity to accumulate savings for retirement are limited. Therefore asset holdings for this scenario is taken as a lower bound. Second, if an agent faces low benefits together with a low payroll tax, savings will be high to offset low benefits in the future. This clearly constitutes a plausible upper bound for asset holdings. Note that optimal asset holdings for an agent who believes the current infeasible system will stay forever lies in between asset holdings for "low benefits – low taxes" and asset holdings for "high benefits – high taxes".

4.2 Calibration

In order to obtain numerical solutions for the model and compare simulations of different scenarios, plausible parameter values were chosen. Our choices, which also contain alternative parameters for a sensitivity analysis, are summarized in table 1 and will be explained in more details below and in appendix B.

The overall demographic structure was taken from a population scenario of the "Schweizerisches Bundesamt für Statistik" *(SBfS)*. The chosen scenario underlies a moderate immigration, a relatively low fertility rate and a slight decrease in mortality rates. Using forecasted population numbers for several years until the year 2040, the fraction of people in each age group for both the entire population and for Swiss citizens (to determine the age of the median voter) was computed. The age of the the median voter—which would be 48 years in a stable population—was 45 in 1995 and is forcasted to increase to 47 by 2010, and to 52 by 2025.

	Parameter	*benchmark*	*alternatives*
Ψ_j	survival probability	Swiss census 1980	
β	discount rate (per year)	1.011	1
θ	consumption/leisure	0.33	0.4
σ	risk–aversion	4	2, 8
e_j	relative productivity	Hansen (1993)	(heterogenous)
r	real interest rate (per year)	3%	1%, 5%

Table 1: Parameter values and factor prices for calibration and sensitivity analysis.

4.3 The public pension system and the size of the reform

The initial payroll tax rate, used for our analysis is chosen to be 10.38% which corresponds to the implied tax rate in Switzerland in 1990.[7] At present, only tax revenues on alcohol and tobacco consumption are used to finance social security in Switzerland. However, when consumption taxes were introduced in 1994, voters agreed on a clause which allows a certain increase in the consumption tax rate to finance pensions.

The benefit level is defined relative to the wage rate (which is normalized to 1). For a benchmark case without a linkage between contributions and benefits, it is chosen in a way that the public pension system in 1990 is balanced, as in the actual economy. Thus $B = .18$ for the benchmark case. The initial retirement age was chosen to be 65 years (corresponding to period 10 in our economy) which is the current retirement age for men.[8] The values for τ and B correspond to a replacement rate—defined as the ratio between the

[7] The proportional payroll tax directly earmarked for public pensions is 8.4% for employed, and 7.4% for self–employed people (1990). 20% of aggregate benefits are financed by general government revenues which are predominantly paid by payroll taxes too. The chosen value understates the true rate for higher income and overstates it for low income, as federal taxes are fairly progressive.

[8] At present, the legal retirement age is 62 for women and it will be raised to 64 years in the next 10 years.

benefit level and average pre–retirement income—of approximately 45%, as in the Swiss economy.

In order to obtain the necessary degree of a change in the pension parameters, we proceed as follows. Using the *SBfS* population scenarios and projecting constant fertility and immigration rates thereafter, the necessary adjustment for a reform, which provides a sustainable pension system in the long run, would approximately be a doubling of payroll taxes. Although this may seem extreme, similar estimates for Germany (Börsch–Supan (1991)) and other countries (den Noord & Herd (1994)) forecast an increase in contribution rates of the same magnitude, should the current benefit structure be maintained. The benchmark scenario is therefore a 100% increase in payroll taxes. Corresponding changes in the other parameters are then computed for a population structure consistent with forecasted fertility and immigration rates. The resulting tax rates, benefit levels and retirement ages are summarized in table 2.

Economic growth and immigration lessen the degree of the necessary reform to a certain extent. Therefore, we also present the results for a situation in which the increase in payroll taxes, which leads to a balanced system, is only 50%. This number—which approximately corresponds to a situation with an annual growth rate of 1.8%—lies in the range of the estimated changes for most European pension systems, derived in the admitedly optimistic analysis of Chand & Jaeger (1996). The implied adjustments to the other parameters of the system are again summarized in table 2.

5 Results

From the six potential pairs, five will be considered below. The sixth—a comparison between an increase in the retirement age and a reduction in benefits—will not be considered for the following reason. As both stabilization policies will have to lead to the same reduction in lifetime income, working agents are indifferent between the two policies. However, once an agent surpasses the current retirement age, his utility is much higher if

	Status quo	*Benefit reduct.*	*Payroll tax incr.*	*Consum. tax incr.*	*Retirem. age incr.*
Benchmark case					
Benefits B	0.18	0.095	0.18	0.18	0.18
Payroll tax τ	0.1038	0.1038	0.2076	0.1038	0.1038
Consumption tax ν	—	—	—	0.0725	—
Retirement age J^*	65	65	65	65	$73\frac{3}{4}$
Smaller reform					
Benefits B	0.18	0.124	0.18	0.18	0.18
Payroll tax τ	0.1038	0.1038	0.155	0.1038	0.1038
Consumption tax ν	—	—	—	0.037	—
Retirement age J^*	65	65	65	65	70

Table 2: Reform scenarios for benchmark case and a smaller reform. Benefit levels are computed for a wage rate 1 per efficiency unit of labor. $B = 0.18$ corresponds to a replacement ratio of approximately 0.45.

the retirement age is increased, as he has already had some of the benefits of the infeasible system. A vote would therefore unambiguously lead to an increase in the retirement age.

For all reform combinations under consideration, the contour plots show the indifference lines as described in sections 2.3 and 4.1. The line labeled "0" represents the indifference–locus $J_0(a)$ between the two stabilization measures in the age/savings plane. Other lines depict the difference between the two reforms with respect to the difference in lifetime consumption. Positive labels denote regions where the latter reform is prefered over the former.

5.1 Benchmark case

For our benchmark case, it is assumed that benefits B are independent of both an agent's age as well as on contributions during his/her lifetime, therefore

$$B_j = \begin{cases} 0, & j < J^* \\ B, & j \geq J^* \end{cases}$$

This simplifying assumption can be justified in view of the rather complex linkage between social security payments and future benefits in most countries. The individual believes that marginal social security tax payments provide no marginal benefits.

The results of these comparisons are summarized in table 3 and depicted in figure 1. In all cases, preferences are single–peaked, and therefore majority voting equilibria always exist. Given our results, it seems impossible to reduce benefits in a direct democracy, although a "new–born" agent has a much larger utility with low benefits and low taxes. This result confirms Browning's claim that public pension systems will be too large in a democracy. The payroll tax dominates most other policies although it is clearly the least efficient means of financing pensions. As in Browning (1975), the problem arises because contributions and benefits occur at very different ages of the life–cycle. At the time of the vote, agents who have benefitted from low taxes and a low retirement age will not want to have their pensions reduced or to contribute to financing the system by means of a consumption tax.

A more interesting result is that an increase in the retirement age is not only a far more plausible outcome of collective decision making than a benefit reduction, but might also be able to outperform an increase in payroll taxes and especially in consumption taxes under certain demographic conditions. When comparing an increase in retirement age with an increase in payroll taxes, people above age $73\frac{3}{4}$ are not affected by either policy and are therefore clearly indifferent between the two options. When comparing an increase in retirement age with an increase in consumtion taxes, there are two distinct age groups—the young and people beyond the new retirement age—who clearly prefer the former policy. In both pairwise comparisons, the mapping from age to the utility ratio is not monotonous. The political acceptance of reforming the pension system by increasing the retirement age depends on the combined weight of the two groups of people under approximately 40 and those over approximately 70–75. It will consequently be less likely when baby–boomers are middle–aged, as they soon will be in most western countries.

The results, moreover, demonstrate how much wealth holdings (as a proxy for past expectations) is a crucial variable in determining preferences regarding policy options. While the size of accumulated assets is of minor importance for comparisons between a reduction in benefits (or an increase in retirement age) and an increase in any of the tax rates, comparing consumption and payroll exhibits a distinct wealth pattern. People with larger savings prefer an increase in payroll taxes over an increase in consumption taxes, as they are relatively more affected by the latter tax. Note, however, that in the absence of heterogeneity with respect to earnings opportunities, larger asset holdings are not a consequence of better income opportunities, but are rather due to precautionary savings in view of a possible reform. Having saved so much, the agent choses to work less in the remainder of his life and is consequently less succeptible to increases in the payroll tax. The more an agent has saved prior to the reform, the more (less) he favours an increase in payroll taxes (consumption taxes) over a reduction in pension benefits Note again that all agents have the same productivity profile, and that consumption taxes are more distortionary for higher level of wealth.

figure 1 near here

5.2 Adding tax–benefits linkages

In this section, we take the perspective that agents are fully aware of a benefit–tax linkage in the public pension system. Results are presented for the following schedule, defined as

$$B = \begin{cases} 0, & j < J^* \\ \alpha \sum_{i=1}^{J^*-1} (1 - l_i) e_j w & j \geq J^* \end{cases} \tag{6}$$

Consequently, past contributions do not bear interest, as is the case for many countries including Switzerland. The benefit formula, moreover, reflects the empirical regularity that contributions towards the rest of an agent's working life often carry a greater weight in computing the benefit level than contributions at the beginning of one's career.[9]

We consider the following reform options: First, leaving tax rates unchanged, a reduction in the parameter α is considered, which amounts to an implicit benefit reduction, necessary to balance the system in present value terms. Second, leaving α unchanged, the payroll tax τ is increased to balance the scheme. Note that this option is equivalent to a benefit–defined scheme and obviously favours the elderly. Finally, leaving payroll tax rates and benefit formula unchanged, consumption taxes are increased to fill the gap between aggregate contributions and aggregate benefits.

In addition to an immediate change after the reform, we also consider a situation where the elderly are grandfathered to a certain extent. We assume a rather generous scheme, where only the very young face an immediate change of the benefit formula. Let us assume that the new formula after the reform contains a (reduced) parameter $\tilde{\alpha}$. The relevant adjustment for each age j will then be computed as

$$\tilde{\alpha}_j \equiv \tilde{\alpha} + (\alpha - \tilde{\alpha}) \frac{j-1}{J_{\max}}. \tag{7}$$

[9] We have also explored alternative assumptions about B_0 and α. The differences in the choice of reforms, however, were relatively small. The larger the value of B_0, which represents the benefit part unrelated to past contributions, the more the results resemble the case whithout tax–benefit linkage.

The results of a simulation with a tax–benefit linkage are depicted in figure 2 for both an immediate and a slow (age–adjusted) change of the benefit formula according to formula (7). Unlike the analysis without tax–benefit linkages, the dashed line in figure 2 represents an estimated measure of total asset holdings, including virtual savings due to the linkage as derived in section 3.1. It is computed for naive agents, who do not expect any reform, and therefore underestimates the true amount of combined wealth. The level of asset holdings, however, only plays a minor role in determining preferences regarding policy options.

The inclusion of a tax–benefit linkage shifts the indifference band slightly to the right, i.e. to higher ages. Therefore an (implicit) reduction of benefits, induced by a change of the benefit–formula, becomes more likely. This result is due to the fact that apart from the usual savings channel, the tax–benefit linkage opens up an additional channel to provide sufficient fund for retirement. After the reform, agents can increase their labour supply which in turn increases their future claims to the pension system. Although the median voter is still weakly in favour of an increase in either the payroll tax or the consumption tax rate for an immediate adjustment, she/he might well be in favour of cuts on the benefit size when the grandfathering scheme is generous enough. The more reforms are postponed, however, the higher the necessary defree of grandgathering will have to be due to unfavourable demographic conditions.

figure 2 near here

6 Sensitivity analysis and model extensions

As is always the case with numerical models, the results are presumably sensitive to the choice of parameters. In our setting, also the size of the reform as well as some of the deep structure of the model potentially have an impact on the outcomes. The analysis here is therefore divided into five parts: First, a sensitivity analysis with respect to the calibrating parameters, as summarized in table 1, is carried out. Then we explore what happens if the reforms are carried out slowly. As a third variation, we consider a situation in which the size of the necessary reform is smaller than in the benchmark case. The inclusion of hererogenous agents with different productivity profiles is considered next. As a last step, the impact of altruism is investigated.

Although all changes to the model have been carried out for all possible comparisons of reform option, results are primarily presented for a comparison between an increase in payroll taxes and a reduction in benefits. The outcomes are presented in table 3 and figures 3–7 in appendix C.

6.1 Variations in calibration parameters and factor prices

The choice of parameters has a relatively small impact on individual's (and therefore society's) preference orderings as is obvious from table 3. The largest influence stems from the real interest rate r. A small interest rate depresses savings and therefore makes individuals more vulnerable to benefit reductions. However, we still observe the same preference orderings, albeit with different indifference ages. The impact of the real interest rate decreases for larger values of r. The analysis shows that while the choice of preference parameters is not very critival, the choice of constant factor prices may not be an innocuous choice.

6.2 The speed of the reform

Until now we have assumed that reforms are introduced without a transition period. That is after the vote, benefits will be reduced and taxes increased without a delay. Obviously this is not always a very realistic assumption, as often benefits are only reduced gradually and tax increases extend over a lengthy period. In this section we therefore assume that following the vote benefit reductions or tax increases are spread out over a period of 20 years (or four 5–year periods).[10]

[10] Spreading out necessary changes leads to an additional strain on the countries budget. In view of the fact that the transitional burden is relatively small (compared to the overall burden of an unbalanced pension

Model		*Reforms*		*Indifference age*	*1% – range*	*winner*
Benchmark		B	τ	39	37 – 41	τ
		B	ν	37	34 – 41	ν
		J^*	ν	44 & 71	40 – 47 & 70 – 73	J^*
		J^*	τ	42 & $\geq 73\frac{3}{4}$	40 – 44 & ≥ 73	
		τ	ν	40	36 – 44	τ
Sensitivity	$r = 0.01$	B	τ	30	27 – 33	τ
	$r = 0.05$	B	τ	43	41 – 45	τ
	$\sigma = 2$	B	τ	37	35 – 40	τ
	$\sigma = 8$	B	τ	40	38 – 42	τ
	$\beta = 1$	B	τ	40	38 – 42	τ
	$\theta = 0.4$	B	τ	42	40 – 42	τ
Slow reform		B	τ	32	29 – 35	τ
		B	ν	31	25 – 35	ν
		τ	ν	33	28 – 38	τ
Small reform		B	τ	34	30 – 38	τ
		B	ν	30	20 – 36	ν
		J^*	ν	36 & 69	27 – 43 & 68 – 70	
		J^*	τ	38 & ≥ 70	34 – 42 & ≥ 70	
		τ	ν	39	32 – 46	τ
Heterogeneity		B	τ	n.a.		τ
Altruism	$\gamma = 0.5/j$	B	τ	46	43 – 49	
	$\gamma = 1/j$	B	τ	53	50 – 56	B
	$\gamma = 0.25$	B	τ	44 & ≈ 80		
	$\gamma = 0.5$	B	τ	51 & ≈ 74		B

Table 3: Approximate indifference age (and 1% age – range) for various pairwise comparisons. (“n.a.” = median voter approach not applicable). The winning reform is only given if it is unambiguous.

Results are shown for three bilateral comparisons in table 3. A gradual reform lowers the threshold age for which agents are indifferent between a benefit reduction an an increase in either payroll taxes or consumption taxes. For young agents up to age 45, a slow reduction in benefits is unimportant as they will experience a low pension anyway. On the other hand, a gradual introduction of higher taxes is obviously more attractive as an immediate one. A similar argument can be made for the retirees. Although a gradual reduction in benefits is better than an immediate cut, both payroll taxes and consumption taxes are far more attractive as they are predominantly levied on younger agents. For the middle–aged, gains from a gradual reform are approximately equal for each reform.

6.3 The size of the reform

Decreasing the size of the reform (as summarized in table 2) has implications on the reform's efficiency. Although a reduction in benefits or an increase in retirement age are still the economically most efficient adjustments of the system, the difference in utility relative to these policy changes—measured by a fraction of life time consumption—shrinks to 2.9% for an increase in payroll taxes and to a mere 1% for an increase in consumption taxes. This also means that the distortion on labour supply is relatively small. As expected, indifference bands are wider, as utility level differ far less between the competing reforms. The ranking of pure reforms remains the same. The smaller reform size, however, favours increases in tax rates even more. The relatively smaller efficiency gains of a reduction in benefits are apparently outweighted by the effect that past tax contributions are sunk.

6.4 Heterogenous agents

The assumption of homogeneity within a generation can be challenged on various ground. People do not only differ by their age but also by their wealth and, even more importantly, by their earnings opportunities. While we have partially accounted for different wealth levels

system) we abstract from this issue here.

by considering a wide range of asset holdings at the time of the vote, we have neglected heterogenous productivity profiles so far.

In this simulation exercise, we consider two extreme groups of people, “rich” and “poor”, with different productivity profiles as described in appendix B and depicted in figure 6. As before, benefits B do not depend on past contribution, so that the replacement rate for “poor” agents is approximately 2.5 times higher than for “rich” agents. Individual preferences depend on the agent’s type. A rich agent’s labour supply decision is distorted far more by an increase in payroll taxes than a poor agent’s allocation. In addition, a reduction in benefits hurts a rich person less than a poor person as the relative wealth effect is much smaller. Consequently rich agents favour a benefit reduction (over either tax increase) to a more advanced age than poor agents. Although preferences differ considerably, the overall picture remains more or less unchanged. As the median voter model does not apply here, we simply compute the fraction of people in favour of either reform. For a comparison between an increase in payroll taxes and a reduction in benefits, we get the following numbers (corresponding numbers for homogenous agents in parenthesis) for the year 2000 (median voter 47): 26% (32%) favour a benefit reduction, while 74% (68%) prefer a payroll tax increase. For approximatelely 10% of the agents, remaining lifetime utility differs by less than 1%.

If it is assumed that all agents participate in a vote, the resulting reform will unambiguously be an increase in tax rates. However our results become important when considering representative democracies. In this latter setting, certain subgroups of the population as well as certain age groups are admittedly overrepresented in parliament. It might as well be that the composition in parliament is such that an outcome of a vote would not be in favour of an increase in taxes.

6.5 The inclusion of altruism

If people do care about the well–being of their offsprings, the results will probably change. In order to get an idea of how the choice of the reform might be influenced, we consider a very simple form of altruism: When comparing reforms, the individual will also take into account the welfare of future generations, measured by the utility of a new born individual $\mathcal{U}_0^s$. This latter measure can be thought of as representing the discounted sum of all future generations, provided the system is believed to stay unchanged.

More formally, we assume that an age–j agent choses the reform which yields the highest overall utility $\widetilde{\mathcal{U}_j^s}$ which is a weighted sum of the remaining life time utility $\mathcal{U}_j^s$ without altruism, and the utility of a new born individual $\mathcal{U}_0^s$,

$$\widetilde{\mathcal{U}_j^s} \equiv \mathcal{U}_j^s + \gamma(j)\mathcal{U}_0^s. \tag{8}$$

The weights $\gamma(j)$ are presumably age dependent. As the number of remaining periods in life decreases, the offspring's utility—which is computed for the whole life cycle—gets an increasingly greater weight, unless γ is decreasing. Moreover, a decreasing degree of altruism towards the young is consistent with empirical evidence (see van der Heijden, Nelissen & Verbon (1997)). For our purpose, four possibilities are explored: $\gamma_j = \frac{0.5}{j}$, $\gamma_j = \frac{1}{j}$, $\gamma_j = 0.25$, and $\gamma_j = 0.5$.

As can be seen clearly from table 3 (and in figure 7 in the appendix), the existence of altruism favours more efficient pension reforms. In particular, a reduction in benefits and an increase in retirement age (not shown) are much more likely when people care about future generations' welfare. Even with a moderate degree of altruism, the age of the decisive voter increases by several years. It is important to note that the inclusion of a bequest motive does not lead to the same results. On the contrary, bequest motives tend to decrease the preference for benefit cuts for elderly and middle–aged people even more as they reduce the possible size of the bequest.

7 Potential extensions of the analysis

A number of further extensions are straightforward. For example, voting models can be adapted to cope with situations where the reform is not decided by a vote but by a utility–maximizing government seeking reelection. In this case, the relevant demographic structure is the actual demographic structure on the reelection date. Moreover we can give different weights to different (age and professional) groups of the society, for example by their representation in parliament or by their degree of organization in lobby groups.

We have neglected alternative ways to reform the pension system. First, reforms can be induced by parameters outside the public pension scheme. In a growing economy, for example, a non–adjustment of benefits to the growth rate, can reduce the burden of the system considerably. Such decisions are usually not taken with a vote. Second, the analysis is confined to reforms within the pay–as–you go financing system. In view of the results derived in section 5, the neglect of not considering a transition to a fully funded system for our analysis can however be justified *ex post* to a certain extent. A transition to a fully funded system has similar welfare consequences for the working generations as a reduction in benefits, as these people, who by their contributions have acquired an implicit claim to future benefits, suddenly face the need to accumulate sufficient funds for their retirement. Moreover, honoring obligations towards the elderly introduces an additional fiscal strain. Unless compensating (efficiency) gains to working generations are sufficiently high, the political pressure against such as shift is presumably large—just as the political pressure against a benefit reduction.

We have merely compared "pure" reforms, with changes in one of the parameters only. Our framework, however, can also be applied to situations in which reforms will entail adjustments along several dimensions. From a policy maker's perspective, one might also ask the question what is the most efficient outcome that can be achieved in a vote. The analysis can serve as a tool in finding the set of welfare improving, but politically feasible transformations of the current pension system.

8 Summary

We have presented a majority voting model to evaluate the possibility of reform options in an infeasible public pension system for an economy with life–cycle agents. To circumvent the problem that expectations prior to the reform are crucial in determining the choice between policy options, individual preferences are derived for a wide range of wealth holdings. On a methodological side, the indifference band approach provides a useful generalization of voting models to a more realistic multiperiod setting, where a certain fraction of the population can be indifferent between two policy options.

Our results extend and qualify the claim of Browning's seminal 1975–paper that public pension systems tend to be too large in a democracy. As taxes and benefits are due in very different periods in life, the outcomes of votes on stabilization policies are often suboptimal. An ageing society will not only increase the financial burden of the system, but will also make economically efficient reforms less likely. With the example of Switzerland, it is shown that in the absence of a benefit–tax linkage, the most likely outcome in a vote is an increase in payroll taxes followed by an increase in retirement age and an increase in consumption taxes. A benefit reduction is dominated by all other options. An economically efficient increase in the retirement age can be an equilibrium outcome, provided the number of very young individuals and/or the number of elderly people beyond the increased retirement age is sufficiently large. In some cases, the median voter's age lies in the indifference range as proposed in the paper, such that the result of a vote can be expected to be ambiguous. The results are remarkably robust to the size of asset holdings, which in turn reflect past expectations. This can serve as an *ex post* justification for a number of simplifiations concerning the voting process, taken by this literature.

Our findings are confirmed in a setting where agents are heterogenous in terms of their labour earnings profiles. If reforms are carried out gradually after a vote, the chance of a benefit reduction is even smaller. An interesting result is that cases in which the necessary size of the reform is large might lead to more efficient outcomes in a democratic process than cases where the necessary adjustments are smaller. The results of our analysis are more robust to changes in the calibration parameters than to assumptions about factor prices and the degree of altruism. A sensitivity analysis with respect to preference parameters σ, θ and β did not change the outcomes of a vote. The inclusion of altruism, on the other hand, has been shown to have important consequences on individual and aggregate preferences. Altruism towards future generations can lead to a more efficient voting outcomes.

Outcomes of collective decision making are more efficient when individuals perceive a linkage between their contributions and future benefits, as the linkage opens up an additional channel to provide for retirement. In contrast to a situation without linkages, individuals prefer an (implicit) reduction in benefits over an increase in payroll taxes to a higher age. This is especially true if elderly beneficiaries are grandfathered to a certain extent in the sense that they get—at least partially—the same benefits they were claiming prior to the change in the benefit formula. A perceived benefit–tax linkage might therefore not only lead to more efficient allocations of life–time ressources, but also partially offset the pressure to increase social security taxes.

The proposed approach can be applied to other policy experiments which entail intergenerational distribution, such as a shift from income taxes to consumption taxes. While the qualitative findings of our setup confirm the previous literature, we are also able to provide quantitative predictions of voting outcomes. Despite the restrictiveness of our assumptions, the model can provide a useful framework for the quantitative analysis of democratic decision processes.

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A Tax–benefit linkage: computations

As is obvious from the budget constraints and equation (5), computing the optimal life–cycle consumption and labour supply profile for an individual agent involves two state variables, asset holdings a_j and a measure of accumulated claims to the system, $p_j \equiv \sum_{i=1}^{j}(1-l_i)f_i$. However, we can simplify the problem as follows: An individual's lifetime budget can be written as

$$\sum_{j=1}^{J^{\max}} \frac{1}{(1+r)^{j-1}}\Big\{(1-l_j)e_j w(1-\tau) - c_j\Big\} + \sum_{j=J^*}^{J^{\max}} \frac{1}{(1+r)^{j-1}} B \geq 0. \tag{9}$$

Using the benefit formula (5) and the formula for arithmetic series, the second term can be expressed as

$$\begin{aligned}
&\sum_{j=J^*}^{J^{\max}} \frac{1}{(1+r)^{j-1}} B \\
&\quad = \left(\frac{(1+r)^{\{J^{\max}-J^*+1\}}-1}{r(1+r)^{J^{\max}-1}}\right)\left[\alpha \sum_{i=1}^{J^{\max}}(1-l_i)f_i\right] + \sum_{j=J^*}^{J^{\max}} \frac{1}{(1+r)^{j-1}} B_0 \\
&\quad = \sum_{j=1}^{J^{\max}} \frac{1}{(1+r)^{j-1}} \left\{\left(\frac{(1+r)^{\{J^{\max}-J^*+1\}}-1}{r(1+r)^{J^{\max}-j}}\right)\alpha(1-l_j)f_j\right\} + \sum_{j=J^*}^{J^{\max}} \frac{1}{(1+r)^{j-1}} B_0
\end{aligned}$$

Substituting this expression into (9) yields the transformed lifetime budget constraint,

$$\begin{aligned}
\sum_{j=1}^{J^{\max}} \frac{1}{(1+r)^{j-1}} \Bigg[(1-l_j)e_j w \left\{(1-\tau) + \left(\frac{(1+r)^{\{J^{\max}-J^*+1\}}-1}{r(1+r)^{J^{\max}-j}}\right)\frac{\alpha f_j}{e_j w}\right\} \\
+ I_{[j\geq J^*]}B_0 - c_j\Bigg] \geq 0.
\end{aligned} \tag{10}$$

Equation (10), however, also represents the lifetime budget constraint of an agent without a tax–benefit linkage, who faces an age–specific payroll tax $\tilde{\tau}_j$, where

$$\tilde{\tau}_j \equiv \tau - \frac{\alpha f_j}{e_j w}\left(\frac{(1+r)^{\{J^{\max}-J^*+1\}}-1}{r(1+r)^{J^{\max}-j}}\right).$$

By transforming the system, we have arrived at a unique state–variable $\tilde{a}$. While uncovering the claim variable p is straightforward, the original level of asset holdings a in the untransformed system can be uncovered as follows: In every period j, $\tilde{a}_j$ contains a certain amount of “virtual savings” VS_j, corresponding to the present value of pension claims;

$$\begin{aligned}\mathrm{VS}_j &= (1-l_j)e_j w(\tau-\tilde{\tau}_j)\\ &= (1-l_j)\alpha f_j\left(\frac{(1+r)^{\{J^{\max}-J^*+1\}}-1}{r(1+r)^{J^{\max}-j}}\right). \end{aligned} \tag{11}$$

In the transformed sytem without linkages, VS_j represent the accumulation of funds for retirement. These amount to an aggregate “virtual savings” AVS_j at the end of period j,

$$\begin{aligned}\mathrm{AVS}_j &= \sum_{i=1}^{j}(1+r)^{j-i}(1-l_i)\alpha f_i\left(\frac{(1+r)^{\{J^{\max}-J^*+1\}}-1}{r(1+r)^{J^{\max}-i}}\right)\\ &= \left(\frac{(1+r)^{\{J^{\max}-J^*+1\}}-1}{r(1+r)^{J^{\max}-j}}\right)\sum_{i=1}^{j}(1-l_i)\alpha f_i \end{aligned} \tag{12}$$

Pure asset holdings of an age–j–agent are therefore $a_j = \tilde{a}_j - \mathrm{AVS}_j$.

B Calibration: preference parameters

We will use the constant intertemporal elasticity of substitution specification (2.2). The coefficient of relative risk–aversion σ (or the inverse of the intertemporal elasticity of substitution) is chosen to be 4, following Auerbach & Kotlikoff (1987) and Ríos-Rull (1996). The coefficient θ which defines the tradeoff between consumption and leisure is chosen to be 0.33. According to Ríos-Rull (1996), this value generates an age–profile of hours worked that is very similar to observed profiles.

Detailed data on labour earnings profile are not available for Switzerland. We therefore use the index of relative efficiency (as a proxy for labour earnings profiles) for individuals of different ages, computed by Ríos-Rull (1996) with data from Hansen (1993). Preliminary data collected by the *SBfS* suggest a close accordance with the relative efficiency as computed by Ríos-Rull. In order to get a more realistic setting with heterogenous agents, we also construct (an artificial) subdivision of society into rich (1/3 of population) and poor (2/3) agents. Poor agents have a completey flat labour productivity profile and reach roughly 63% of an average agent's productivity over the life–cycle. A rich agent's profile is pronouncedly hump–shaped with an average labour productivity of approximately 170% of Hansen's efficiency level.

The pure discount rate β is assumed constant and is taken from Hurd (1989). Hurd argues that most estimates for the rate of time preference are upward biased if mortality risks are not accounted for. For yearly intervals, he estimates $\beta = 1.011$. We therefore use the value $1.011^5 = 1.056$ for our 5–year intervals. Future levels of utility are not only discounted by the pure discount rate β, but also by the probability Ψ_j to live until age j. The combined discount rate $\Psi_j \beta^{j-1}$ for time j instantaneous utility is therefore time–dependent. Note, that the combined discount rate for $\beta = 1$ is always strictly less than 1.

C Figures to section 6

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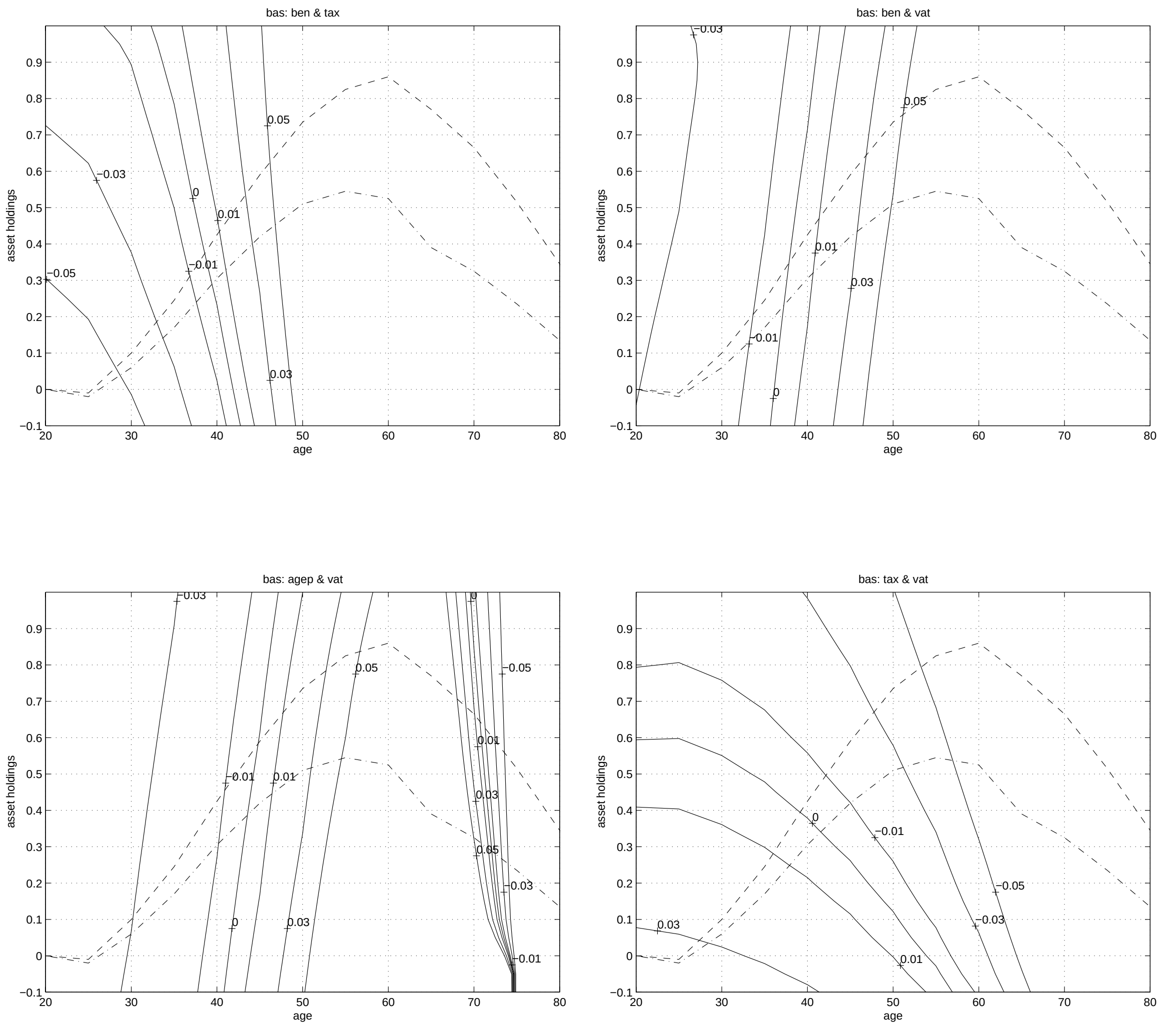

Figure 1: Utility comparisons between reforms in the benchmark case. The contour lines depict the fraction of remaining lifetime consumption the second reform yields in comparison to the first. (ben $\Rightarrow$ benefit reduction, tax $\Rightarrow$ payroll tax increase, vat $\Rightarrow$ consumption tax increase, agep $\Rightarrow$ increase in retirement age)

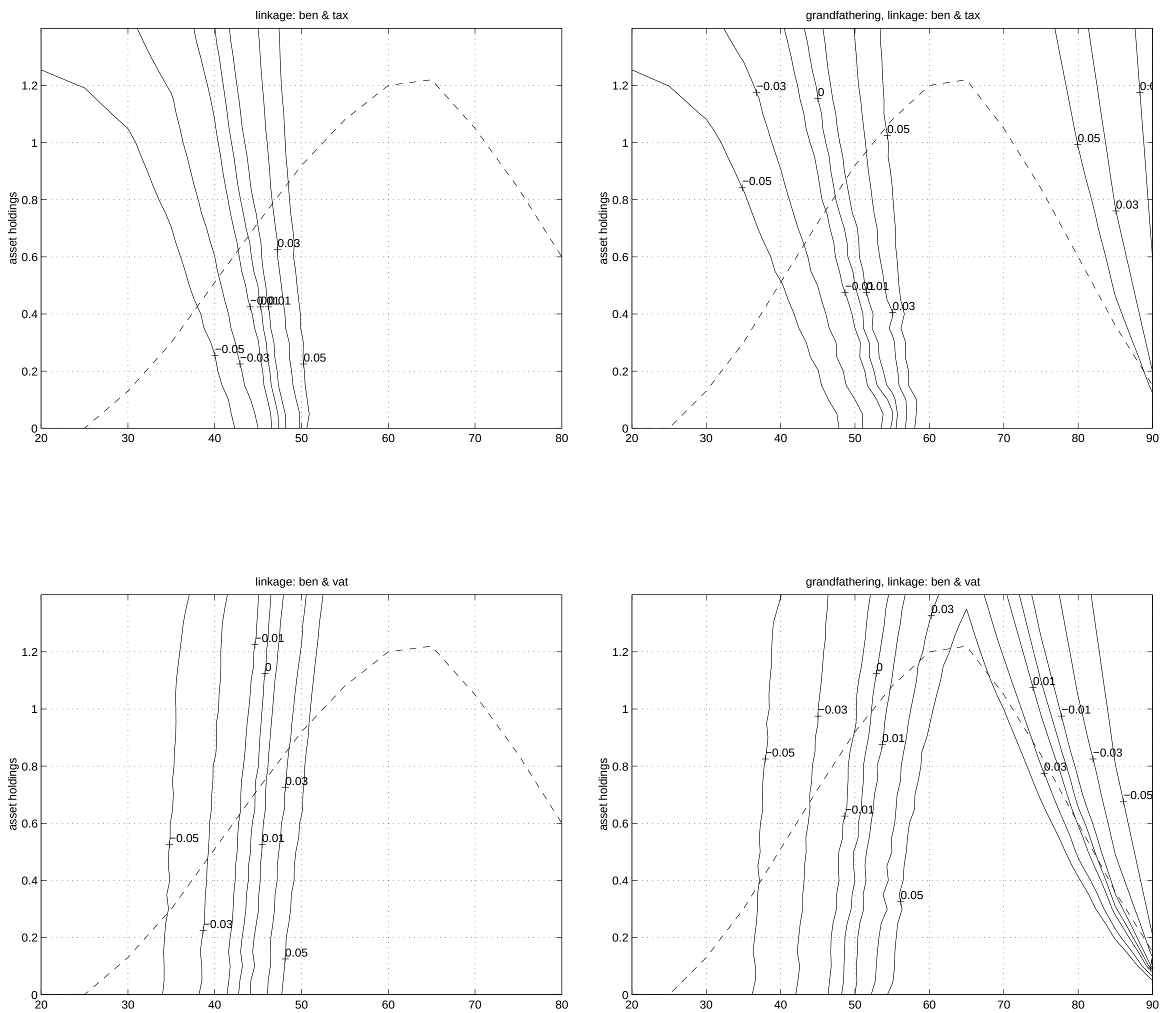

Figure 2: Utility comparisons with a perceived tax–benefit linkage. Tax–benefits links are either adjusted suddenly or slowly (grandfathering), and tax increases are immediate. The contour lines depict the fraction of remaining lifetime consumption the second reform yields in comparison to the first. (ben $\Rightarrow$ benefit reduction, tax $\Rightarrow$ payroll tax increase, vat $\Rightarrow$ consumption tax increase)

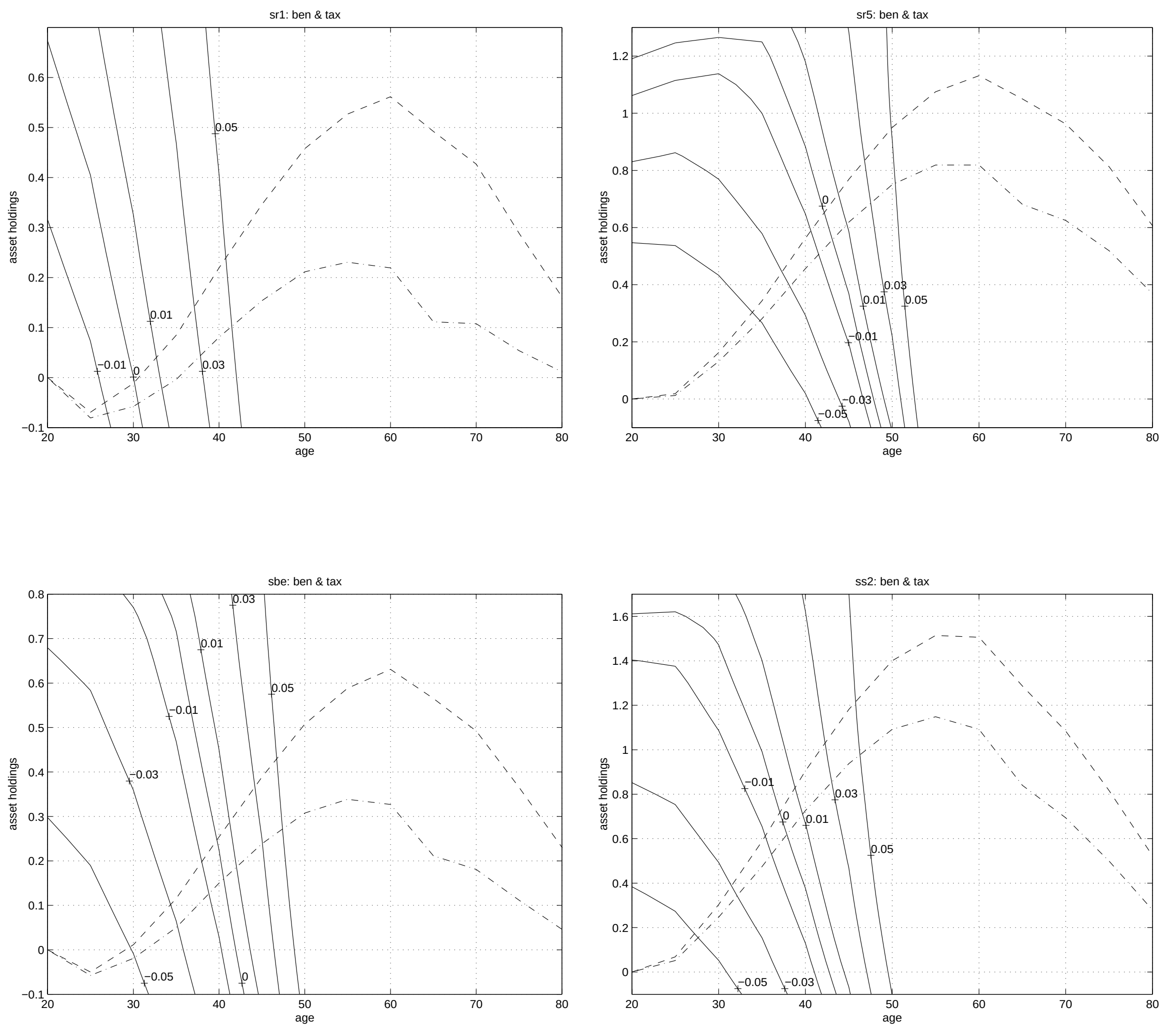

Figure 3: Utility comparison between a reduction in benefits (= ben) and an increase in payroll taxes (= tax) for a number of alternative parameter values. (sr1 $\Rightarrow$ interest rate $r = 0.01$, sr5 $\Rightarrow$ interest rate $r = 0.05$, sbe $\Rightarrow$ pure discount factor $\beta = 1$, ss2 $\Rightarrow$ risk aversion $\sigma = 2$.)

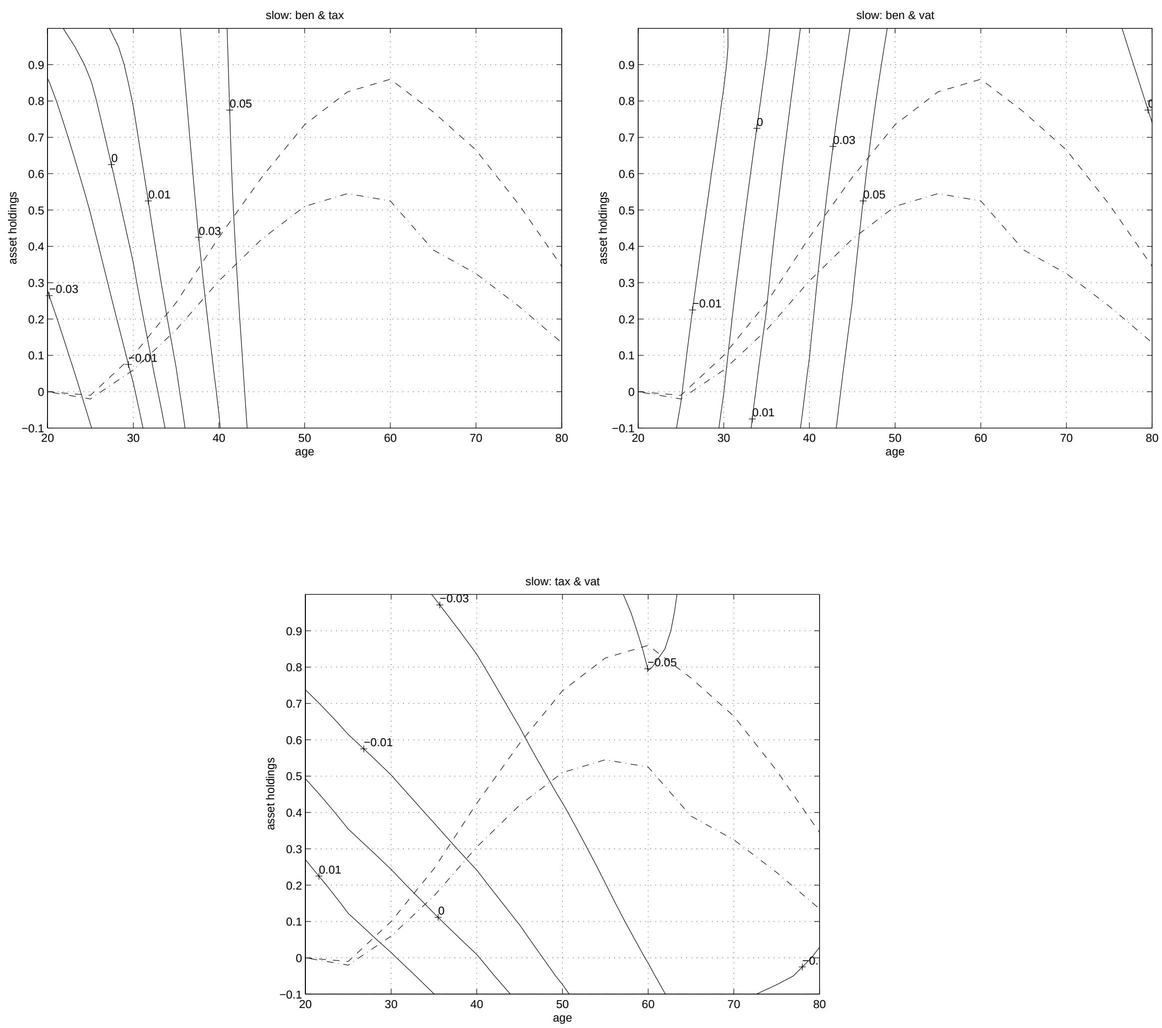

Figure 4: Utility comparisons between reform options for slow reforms. The contour lines depict the equivalent consumption reduction of the second reform in comparison to the first. The contour lines depict the fraction of remaining lifetime consumption the second reform yields in comparison to the first. (ben $\Rightarrow$ benefit reduction, tax $\Rightarrow$ payroll tax increase, vat $\Rightarrow$ consumption tax increase)

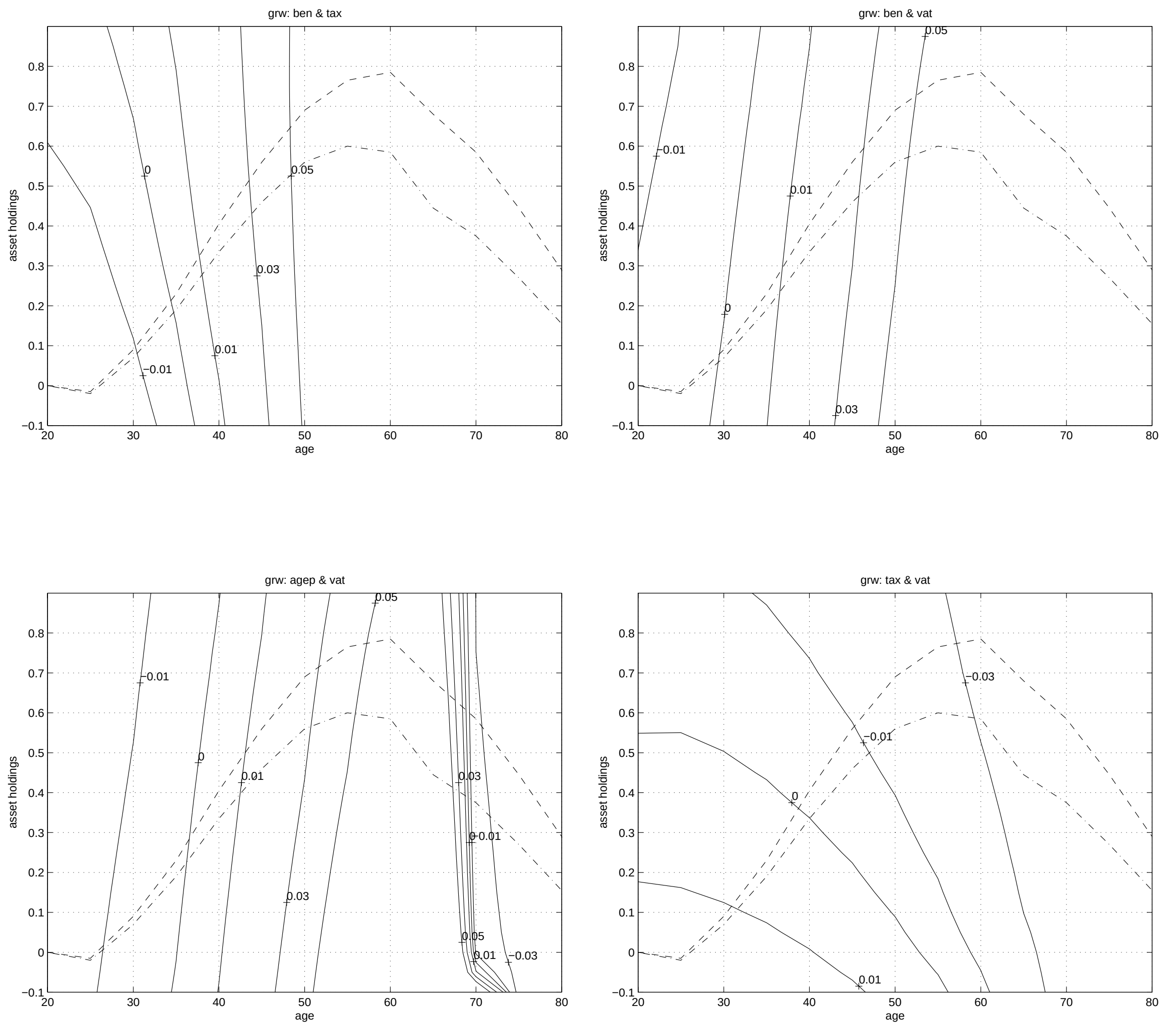

Figure 5: Utility comparisons between reform policies for a smaller reform. (ben ⇒ benefit reduction, tax ⇒ payroll tax increase, vat ⇒ consumption tax increase, agep ⇒ increase in retirement age)

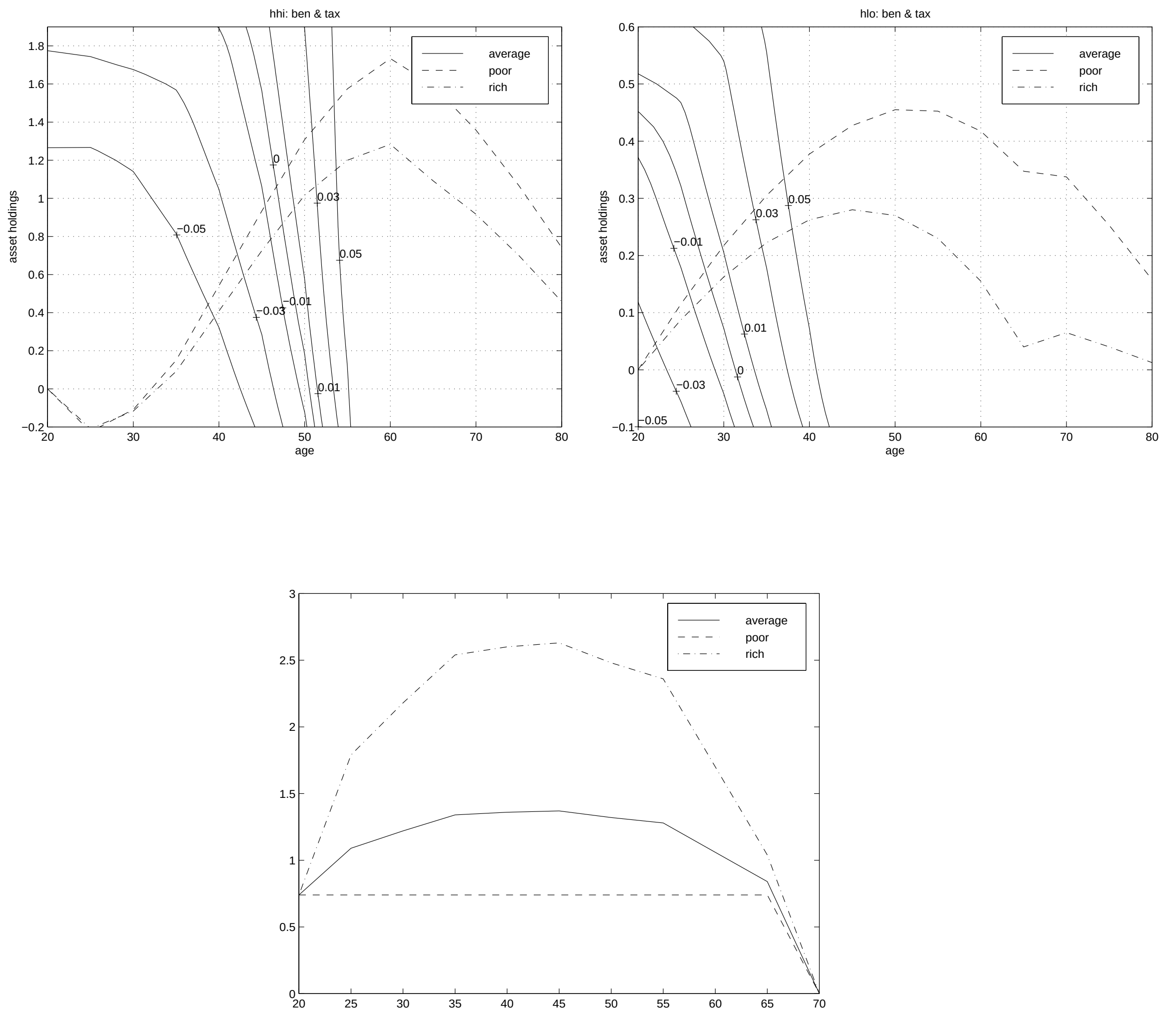

Figure 6: Utility comparisons between a reduction in benefits (= ben) and an increase in payroll taxes (= tax) for heterogenous agents. The lower panel shows the used labour earnings profiles.

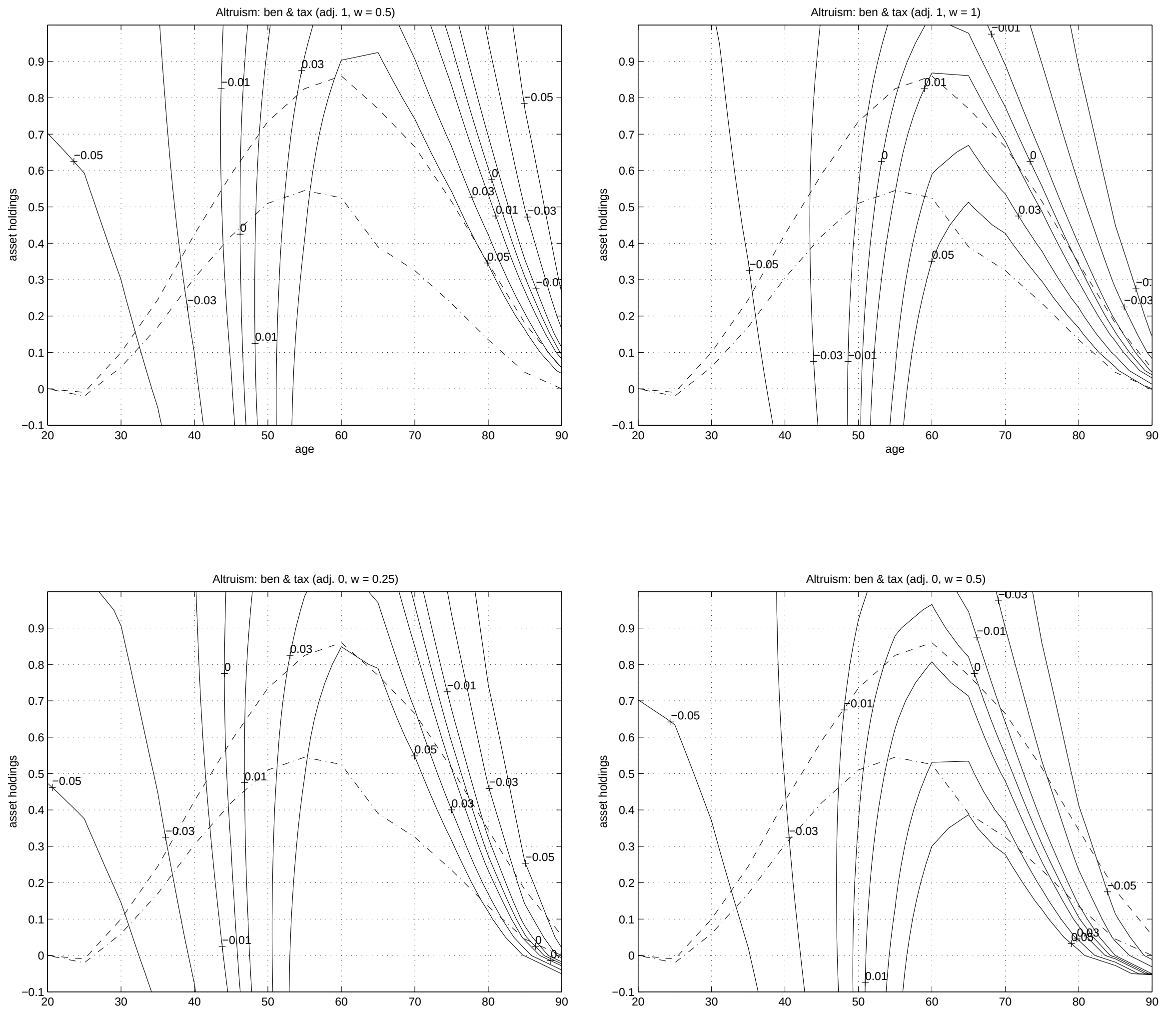

Figure 7: Utility comparisons between a reduction in benefits (= ben) and an increase in payroll taxes (= tax) for various degrees of altruism. The contour lines depict the fraction of remaining lifetime consumption a payroll tax increase yields in comparison to a reduction in benefits.